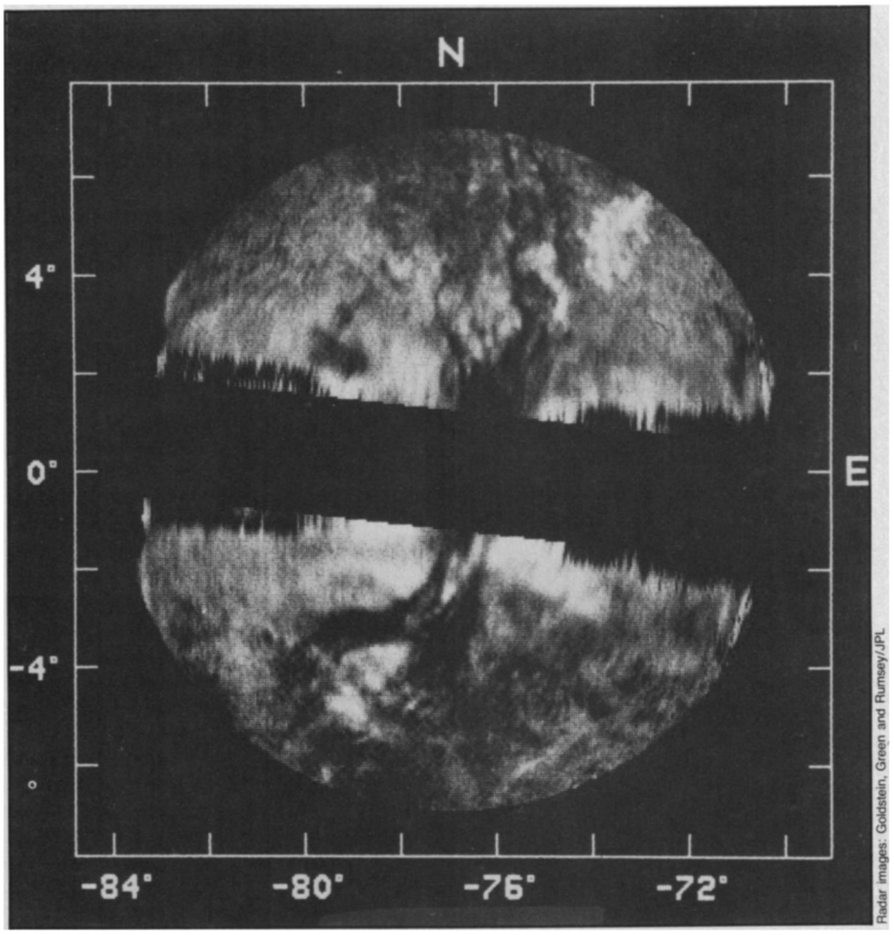
Venus: Hints of a Dynamic Planet

Earth may be the only planet in the solar system that is still being molded and altered by the geologic processes that have been changing it since its birth. Researchers such as the more than 200 members of the American Astronomical Society's Division of Planetary Sciences, who met in Austin last week, would love to find another, but the problems of looking are substantial. Pluto is too far away. Jupiter, Saturn, Uranus and Neptune are too deeply immersed in their atmospheres, or too distant, or both. Mercury seems to show a few compressional features, but they are probably relics of an ancient, more exciting time. Even earth's moon, despite occasional seismic twitches, looks to be an aged world evolved to senility.

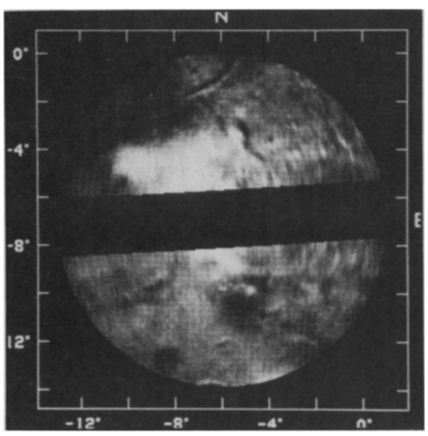
There are only two other major candidates: Venus and Mars. Both have been studied from earth, flown by, orbited and—with greater or lesser success—landed on by spacecraft. There are no definite signs as yet that either world is still "alive," but some scientists believe that there is evidence that can at least be interpreted as keeping the exciting possibility open.

In one fundamental way, the search for a geologically active planet besides the earth has the same motivation as the search for another world with life on it. For all its diversity, life on earth is, at the most basic level, the same, all based on the same biochemical foundations, whether euglena or elephant, mushroom or man. One of the strongest reasons for seeking extraterrestrial life is the hope of finding a different system, of enlarging the list of life systems to some number greater than one. In the same sense, knowledge of "living" planets is so far limited to a single example. The discovery of a second would mean that literally world-shaping processes such as volcanism, crustal tectonics and perhaps others yet unknown could be studied, while they work, in a completely different environment with different stresses, different mixtures of raw materials . . . and different consequences. The result would almost unfailingly be greater insight into the complex workings of our own world.

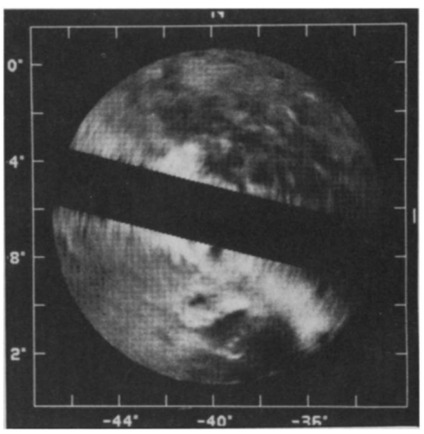
Venus, with its high temperatures and 90 earths worth of atmospheric pressure, is a difficult laboratory to work in. Even its blanket of clouds is nearly featureless except by ultraviolet light. Spacecraft reaching the surface have survived for little more than an hour. In recent years, however, radar studies from earth have started to provide a kind of picture of the veiled planet's rocky ground. Most of the images have come from the work of Richard M. Goldstein and his colleagues at Jet Propulsion Laboratory in Pasadena



Radar image of Venus, covering an area about 1,500 kilometers across, reveals a 1,400-kilometer trough that may indicate a cracking or pulling-apart of the crust.



Fault may have rebent mountain arc.



Depressed peak may be giant volcano.

(SN: 8/4/73, p. 72), using the huge antennas of the nearby Goldstone facility while others are being made by Donald B. Campbell and colleagues at Arecibo.

Now there are images of Venus that suggest that planet is likely to be a very exciting candidate for future exploration. They are a series of radar studies made by Goldstein, together with Richard R. Green and Howard C. Rumsey of JPL, that will soon be published in the JOURNAL OF GEOPHYSICAL RESEARCH. The JPL images show a variety of surface features that seem to indicate the possibility of tectonic activity on Venus.

The most striking feature is a vast,

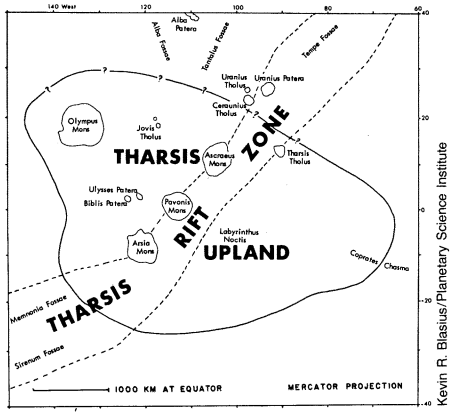
trough-like depression about 1,400 kilometers long and as much as 150 kilometers wide. According to JPL geologist Michel C. Malin, who described the features and his interpretation of them at the DPS meeting, the trough is almost surely an extensional feature—a crack—rather than, say, an erosional one. It is not unlike the East African Rift on earth, Malin says, and is strong evidence of extensional tectonic activity on Venus.

Another of the images shows a portion of a long, curved mountain range, crossed by a less-prominent linear feature. Where the two intersect, the mountain curve appears to be bowed inward, a strong sign, according to Malin, of a possible fault displacement. Elsewhere on the planet is a region of smooth plains containing, in an area about 300 kilometers square, some 15 to 20 peaks, a pattern strongly reminiscent of clusters of volcanoes on earth. Another view shows a single huge peak about 450 by 300 kilometers at its base, containing an 80-kilometer circular depression at its summit. This, Malin believes, marks it as a monstrous volcano, apparently in a class with the now-famous Olympus Mons on Mars, though perhaps not so tall. One image shows a series of roughly parallel mountain ranges separated by valley-like features, possible evidence of compressional tectonics. The implication, Malin says, is that Venus has had a more active tectonic history than Mars, which shows smaller signs of extensional activity and none of compression.

Striking though they are, these features are no indication by themselves that Venus is a currently or even recently active planet. They do, however, suggest an active enough history, according to Malin, that it is conceivable that some activity might still be taking place. Furthermore, he points out, data from Soviet Venera spacecraft have indicated that Venus has uranium and potassium abundances that are more like those of the earth than of the cold, near-dead moon—again, not proof of anything, but at least grounds for hope.

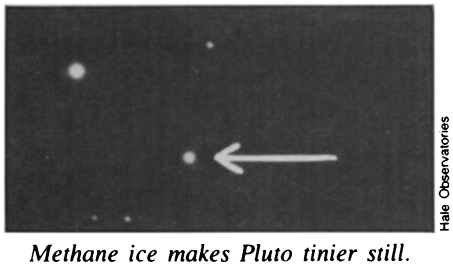
There are intriguing speculations of another sort for Mars. In the region known as Tharsis, the surface seems to be thrust up into a dome-like configuration. This is probably not due to a purely thermal convection cell, according to R.J. Phillips and R.S. Saunders of JPL, since simple cooling would have eliminated the effect in several hundred million years. More likely, Phillips suggested to the DPS members, is that rising material has carried an extra quantity of heat-producing radionuclides. Some researchers, he said, have suggested that it was doming in East Africa that led to the rift zone, when the crust moved away from the local hotspot. Since the Tharsis lithosphere does not seem to have moved away from its apparent hotspot, and since the crust there is probably too weak to hold its domed shape unaided, perhaps some active process is still holding it up.

Kevin Blasius of the Planetary Science Institute in Tucson further suggests that a row of craters across the dome may mean that a "Tharsis Rift Zone" is in the making. In Africa, says Charles A. Wood of Brown University, the younger volcanoes in the rift region are those along



Kevin R. Blasius/Planetary Science Institute

Tharsis plateau may be Martian hotspot.


Hale Observatories

Methane ice makes Pluto tinier still.

the rift itself. Perhaps the row of Tharsis volcanoes is a sign of "some sort of incipient continental fracture."

While some researchers at the meeting speculated on the possible workings of planets in the solar system of today, Dale P. Cruikshank, Carl B. Pilcher and David Morrison of the University of Hawaii reported a discovery about the least-studied planet of all that could offer new insight into the solar system's early years. Using 1.54- and 1.71-micron measurements from the 4-meter telescope at Kitt Peak National Observatory, where the three are visiting scientists, they have detected the substantial presence of methane ice on the surface of Pluto. It is "the first indication," says Cruikshank, "of solid methane in the solar system."

Methane has been theorized as a presence in the primordial nebula from which the planets formed, but so far it has only been found in gaseous form in the atmospheres of Jupiter, Saturn, Uranus, Neptune and Saturn's moon Titan. Since methane in the early nebula would not have frozen solid until the temperature got below −225°C, apparently only frigid Pluto could preserve a solid methane frost, thereby providing the first direct evidence that the temperature was in fact that low when the planet formed.

Until this discovery, Cruikshank says, the lowest-temperature condensate known was methane hydrate, which would have frozen solid at about −185°C. Thus, the solar nebula can now be assumed to have cooled at least 40° further while the process of planetary condensation was still going on. Beyond methane, the next colder condensate would be neon, but the chances of such a discovery are remote indeed. Neon is a noble gas and therefore difficult to detect by remote sensing, but also it would not have frozen solid in the solar nebula until it cooled down to about −265°C—only 8° above absolute zero. Michael H. Hart of the Hale Observatories has theorized that Pluto may have a neon atmosphere (SN: 6/1/74, p. 353), since neon is volatile enough to avoid freezing out while still possessing a high enough molecular weight to keep it from escaping into space. But Pluto's chilling temperatures would not be low enough to turn neon into a liquid, let alone a solid. To create neon "oceans" on Pluto, Hart calculated, would require an atmospheric surface pressure 20 times that of the earth, an extremely unlikely condition.

One of the reasons that it is unlikely is Pluto's small size, and the discovery by Cruikshank's group is likely to mean that Pluto is even smaller than had been believed. The most commonly cited figure for Pluto's diameter is 5,800 kilometers, based on assumed moonlike reflectivity. If the planet is largely ice-covered, as the new evidence shows, it must be substantially brighter than the moon over comparable areas, which means that it must be considerably smaller than the prevailing estimate. In fact, says Cruikshank, if Pluto's albedo (reflectivity) is as high as 40 percent, Pluto may actually be smaller than the less-than-3,500-kilometer diameter of the moon.

It is not yet certain that Pluto is the only solar system body that retains methane ice, Cruikshank says. Measurements of the moons of Uranus and Neptune are still being analyzed, and it is barely possible that the two worlds' brightest moons, Oberon and Triton respectively, may preserve some traces. But the chances are small, and the number of untested bodies is shrinking rapidly. At the DPS meeting, for example, T. Nicholas Gautier, Uwe Fink, Harold P. Larson and R.R. Treffers reported detection of the characteristic spectral absorption bands of water ice on four of Saturn's moons—Iapetus, Rhea, Dione and Tethys—with "no spectroscopic evidence for any other ices or minerals." It would be possible, as one attending scientist pointed out, to have up to 30 percent methane "and never know it, with that much water," but the extremely low temperatures necessary may be unique to Pluto. It is a tiny, unexotic, neglected world, so far away that the National Aeronautics and Space Administration is not even sure it can build space probes to reach it. But it is suddenly a much more interesting place. □